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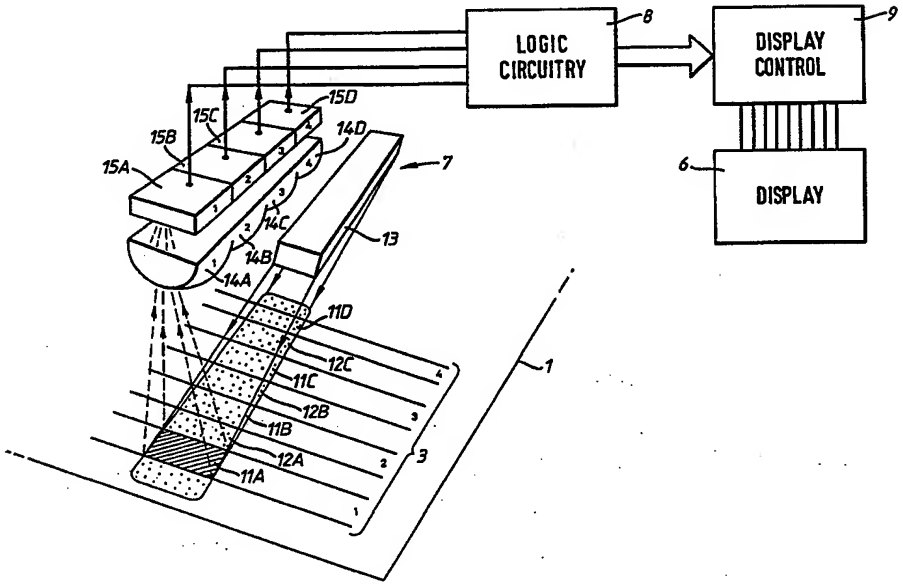
(54) Title: PRINT READING DEVICE



(57) Abstract

A print "reading" device for use in an educational method comprises a printed substrate (1) on which is printed text or images, for example text (2), and related coded information (3) printed in fixed relation thereto. A wand (4) has a viewing window (5) through which a portion of text (2) can be viewed and a code reading device (7) positioned to read coded information (3) relating thereto. Logic circuitry (8) associated with device (7) produces a pre-determined response (10) to the code being read which is displayed on an LCD display (6). The code (3) is suitably a bar code comprising a plurality of bars (11A to 11D) printed in an "ink" which is invisible or only partially visible in normal illumination conditions. The bar code is read using device (7) which comprises a light source (13) and photodetectors (15A to 15D).

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"Print 'Reading' Device"

This invention relates to print 'reading' devices generally, and more particularly but not exclusively to a print reading device having educational applications.

Opto-electronic print reading devices are known *per se*. One such device is described in European Patent Specification No. 0 059 318A and relates to voice synthesis of machine 'readable' text. The essence of the invention claimed in that Specification requires that a synchronisation signal is read from a bar code running alongside the text. This permits the delivery of the synthesised voice output to be independent of the speed at which the text is scanned by a hand held optical reader.

In European Patent Specification No. 0 099 920 text is printed with two types of visually identical ink. One type of ink has different infrared absorption/reflectance characteristics from the other. Utilising this difference a hand held detector pen can be used to identify 'right' or 'wrong' answers to questions printed on the page, and an audio or visual response can be given thereto. The system described in that Specification has been marketed successfully for many years as an educational tool under the Trade Mark QUESTRON. However, this system has limitations. The educational method is essentially binary in character, i.e. the desired ink type either is or is not detected.

A binary system, such as QUESTRON, enables responses to right or wrong answers to be given, but not for example an intermediate response such as "You're close, but think again". Clearly, educational tools which could give any number of intermediate responses would provide a more efficacious learning system because such responses could be used to tutor the pupil as opposed to the simple verification permitted by QUESTRON.

It is an object of the present invention to provide for an improved print 'reading' device having more extensive educational applications than the aforementioned devices.

According to a first aspect of the invention a print recognition apparatus comprises a substrate to which is applied observable printed text

or images and invisible or partially visible machine readable coding, elements of the coding being associated with respective elements of said text or images and having a fixed spatial relation thereto, the apparatus additionally comprising a hand held wand or mouse having a viewing window or port through or at which element(s) of the text or images can in use be viewed, said wand or mouse additionally having a code reading device located relative to the window or port such that the device will read the coding associated with the text image being viewed thereby activating means to produce a predetermined audio or visual response appropriate to that being viewed. The said machine readable coding may be superimposed on said text or images.

Additionally the apparatus may further comprise remotely of said wand or mouse a computer which controls and receives signals from the code reading device and which further processes said received signals to produce the predetermined response.

Preferably, each element of the machine readable coding is a respective bar code comprising a plurality of bar positions each represented by either a bar or a space. Each bar may be printed at one of a plurality of grey scale resolutions. And each bar code may consist of a sum total of four bar positions or a sum total of eight bar positions with alternate positions being control bars adapted for use with a scanning code reading device.

Typically, said code reading device comprises a light source for illuminating a given bar code and a plurality of photodetectors each adapted to receive light reflected from a corresponding bar position of said bar code. Also, said light source may comprise a plurality of LED's each adapted to illuminate a corresponding bar position of said given bar code.

Alternatively, said code reading device comprises a light source for illuminating a given bar code and a single photodetector adapted to reciprocate in a fixed path relative to the window to scan sequentially each bar position of said bar code to receive light reflected therefrom. The said light source may be adapted to scan sequentially each bar position in register with said scanning photodetector. It may comprise a plurality of LED's each of which radiates light of a different wavelength and wherein

said photodetector is adapted to discriminate between said different wavelengths.

Preferably, the window of the wand is glazed with a magnifying lens. And the wand or mouse may further comprise a flat LCD video screen for displaying said visual response.

According to a further aspect of the invention the apparatus as aforedescribed has a code reading device comprising a housing, a light source and a photodetection device, the housing defining a chamber illuminated by the light source from which light is received by the photodetection device, a portion of the interior surface of the chamber being a plain mirrored surface, an aperture in the chamber wall arranged to extend in use over a code segment on the printed substrate, the light source providing a generally collimated beam of light directed from the chamber through the aperture, in which in use the beam is reflected directly from the substrate to impinge on the mirrored surface so as to be reflected through the aperture with the arrangement providing that the beam having been reflected from the substrate at least twice is subsequently received by the photodetection device.

Preferably, the code reading device comprises a plurality of portions of the interior surface being plain mirrored surfaces each adapted in use to direct light reflected from the substrate back through the aperture.

Typically, the non-mirrored interior surface is coated with a retro-reflective substance adapted in use to reflect back stray light received from the printed substrate.

Preferably, the photodetection device comprises a lens arrangement adapted to collect light from the interior of the chamber and focus that light on a photodetector.

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of a first embodiment of the invention;

Figure 1A is a representation of a hand held wand of the first embodiment when in use on a page of text;

Figure 2 is a diagram of the spatial arrangement of a light source and photodetector of a code reading device of the first embodiment illustrated in Figure 1; and

Figure 3 illustrates a photodetection device used in a further embodiment of the invention.

In the preferred embodiment shown in Figures 1 and 1A a page of text is represented by printed page or substrate 1. Associated in fixed spatial relation to an element of the printed text (the text stream 2 being shown in Figure 1A) is a bar code pattern 3 printed in ink which is substantially invisible to the naked eye. Typically, this ink provides that reflectivity of visible light by the bar pattern 3 differs from that by the material of the page 1 by no more than 1 percent in normal lighting conditions. In the embodiment illustrated the text and respective code pattern are spaced apart. Alternatively, one may be superimposed on the other.

The apparatus of the preferred embodiment comprises a hand held wand 4 having a magnifying window 5 and a video display screen 6 and houses a code reading device 7. In use the wand 4 is moved across the page 1 and in answer to, for example, a written question a pupil will view an element of the printed text, i.e. their chosen answer, through the window 5.

The device 7 is controlled by logic circuitry 8 to read bar code pattern 3 associated with the text element viewed through the window 5. Signals received from the device 7 by logic circuitry 8 initiate by means of display control circuitry 9 a predetermined video response 10 displayed on the screen 6. The logic circuitry 8 may be adapted to initiate, as and when appropriate, an audio response by means not shown to supplement or replace the response 10.

This response 10 (and/or audio response) can be one of a plurality of responses represented by the encoding permitted by the bar code pattern 3. For example, in this embodiment the bar code comprises four bar positions 11A to 11D which permits 15 different permutations of coding, i.e. the

possibility of 15 predetermined responses 10. If desired positions 12A to 12C intermediate the bar positions 11A to 11D can be solid bars which can be detected by the device 7 to ensure it is in correct register with the pattern 3.

Code reading device 7 comprises an ultraviolet light bar 13 in use extending laterally of and parallel to the bar code pattern 3, and an array of respectively paired microlenses 14A to 14D and photodetectors 15A to 15D similarly extending laterally of and parallel to the code pattern 3. As can be seen in Figure 2 a photodetector 15A is adapted to receive light 16 from light bar 13 and reflected by bar code position 11A. Likewise photodetectors 15B to 15D are adapted to receive light reflected from code positions 11B to 11D respectively. It will be appreciated that if positions 12A to 12C are 'solid' bars then additional photodetectors (not shown) may be used to detect these.

Although in the embodiment described the light source 13 produces ultraviolet light, the ambit of the invention is taken to include the use of any usable wavelength of light within the ultraviolet, visible and infrared bands. In the Specification reference to machine readable coding being invisible or partially visible is taken to mean that it is difficult to detect by visual inspection under normal illumination conditions, i.e. its presence is not as readily apparent as that of the printed text, for example. This should not be taken to preclude the ambit of the claimed invention being extended to encompass the use of coding which is wholly visible to the naked eye. Also, although the described embodiment uses bar coding the ambit of the invention is to be taken to encompass any other form of 'printed' machine readable coding, such as for example a geometric array or pattern of dots, hieroglyphics, bars, shapes, lines, figures, etc. and/or any combination thereof.

In typical viewing conditions light scattered by the bar code position 11A, for example, will tend to be diffuse. However, different reflection characteristics of plain paper and the ink of a solid bar will be achieved if the light source 13 is arranged so that light 16 therefrom is caused to impinge on the code position 11A at a small glancing angle of incidence alpha(2) as shown in Figure 2. Light reflected at an angle alpha(1) will exhibit significant specular components if reflected from a generally glossy

ink over that which would be detected from light reflected by the generally matt background of the page 1. Such components can be detected readily by a photodetector using means incorporating an electronic thresholding process. Additionally, light scattering from a glossy ink surface will typically have a strong polarisation in the horizontal plane which will further enhance the discrimination between the printed bar code and unmarked paper.

The bar code pattern 3 is made 'invisible' by making the contrast or reflectivity of the bar code ink with respect to the surrounding paper of page 1 small when viewed by a human reader under normal light illumination conditions. This difference in contrast may be achieved by means of 'ink' in the form of varnishes or which are coloured, i.e. with suitable reflective properties, additional to the ink(s) used in the printing of text or images on the page 1. By using grey scaling techniques, for example, it should be possible that the individual bar code segments at positions 11A to 11D can be used to encode further information so that each segment is no longer binary in character. Current understanding of the invention suggests that the code reading devices described could only discriminate a coarse resolution of grey scales, possibly only two levels.

In another embodiment of the invention (not shown) the array of photodetectors 15A to 15D could be replaced by a single photodetection element and the light bar 13 replaced by a plurality of light sources A to D each corresponding to a respective one of the bar code positions 11A to 11D. To read the code these light sources could be switched sequentially so that at any given time the detector records the signal from the corresponding bar code position only.

As an alternative, in yet another embodiment of the invention (not shown) a single illumination source and a single photodetector are mounted so as to reciprocate on a carriage or like means fixed relative to the window 6. To read the code pattern 3 the source and detector are caused to swipe across the entire width of the pattern. It will be appreciated that such an arrangement permits the single source/detector to be used to read the presence of the control bars 12A to 12C if so desired. Typically, the reciprocation of the souce/detector could be effected by a simple mechanical or electro-mechanical device controlled, for example, by the activation of a

button on the wand 4. If desired the photodetector only could be caused to reciprocate whilst the light source remains stationary.

To improve the efficacy of photodetection, if desired the or each light source can be provided by a plurality of LED's each of different wavelengths. These LED's can be imaged to form a single illumination beam or spot. The photodetection device(s) in conjunction with logic circuitry 8 can thus discriminate between wavelengths received if so desired. An advantage of this arrangement is believed to be that a more consistent signal can be achieved for bar codes printed over backgrounds of varying colour.

In a further embodiment of the invention a code reading device 20 such as that shown in Figure 3 is used. In other respects the embodiment is substantially as aforedescribed. For the avoidance of doubt inventive features of device 20 herein described or as claimed are not to be taken to preclude or estop Applicant from filing one or more divisional Application(s) directed solely to this device 20 and/or its application apparatus and methods herein not described.

As hereinbefore described the reading of code depends on the ability of photodetector(s) in conjunction with logic circuitry to differentiate between light reflected from 'invisible' ink and other portions of the substrate which may be plain paper and/or visible ink. So that the ink used is invisible it is desirable that reflectance therefrom differs from the plain page by in the order of less than one percent. Such small differences may be difficult to detect because of the effects of electronic noise, drift and other non-uniformities that may arise in the electronic processing circuitry.

An improved level of discrimination can be obtained if rays from the illumination source are caused to reflect several times from the substrate before illuminating any photodetector. This enables the integrated reflectances to be measured. For example, if the ratio of bar code reflectance to paper reflectance after a single reflection is 1.02 then after 5 reflections the ratio would be 1.02x1.02x1.02x1.02x1.02=1.10 giving greatly improved discrimination.

The code reading device 20 comprises a light proof box housing 21 having sidewalls and a top wall defining a chamber 22 and an aperture 23 at its base. In use the housing 21 is placed on the page 1 so that the aperture 23 extends over machine readable coding. Device 20 further comprises a light source 24 having an LED 25 and a focusing lens 26 adapted to produce a collimated light beam 27 directed through the chamber 22 so as to pass through the aperture 23 and impinge on the page 1 at the position P1. The ceiling of the chamber 22 is provided with two mirrors 28,29. As can be seen from Figure 3, in use light beam 27 is reflected from page 1 at position P1 toward mirror 28 from whence it is reflected back through aperture 23 so as to reflect once more from page 1 at position P2. From P2 beam 27 reflects off mirror 29 through aperture 23 once more to reflect for a final time from page 1 at position P3 into lens 30 of photodetection means 31. Lens 30 is a converging lens having a photodetector 32 of the photodetection means 31 situate at or near its focal point.

Light beam 27 is caused to impinge on page 1 at an angle matched to the known reflected intensity polar diagram of the paper of page 1. This permits the maximum reflection therefrom.

It will be appreciated that light reflecting off page 1 will to a certain degree scatter because the page is not a plain mirror. For example, at position P1 stray light such as rays R1,R2,R3 will also be reflected from the surface. Rays such as R3 will be collected by lens 30 whilst those such as R1,R2 will impinge on non-mirrored surfaces 33 of the ceiling of the chamber 22. Suitably, these non-mirrored surfaces 33 are coated with a retro-reflective substance which cause rays to reflect back along their path through aperture 23 once more. After repeated reflection from page 1 these rays such as R1,R2 will be received by the lens 30. However, unless these rays are caused to reflect from one or other of the mirrors 28,29 their angle of incidence at lens 30 will be too great for them to be focused on detector 32.

Collecting stray light in the aforedescribed fashion reduces the losses of light by stray deflection so that the detected light at detection means 31 is subject to losses substantially only due to the reflectivity of the page 1 or ink printed thereon. As an alternative or supplement to retroreflective surfaces 33 to mitigate the effects of scatter mirrors 28,29

could be curved parabolic mirrors collecting light from a greater area than that of collimated beam 27.

CLAIMS:

1. Print recognition apparatus comprising a substrate to which is applied observable printed text or images and invisible or partially visible machine readable coding, elements of the coding being associated with respective elements of said text or images and having a fixed spatial relation thereto, characterised in that; the apparatus additionally comprises a hand held wand or mouse (4) having a viewing window or port (5) through or at which element(s) of the text or images can in use be viewed, and in that said wand or mouse additionally has a code reading device (7) located relative to the window or port (5) such that the device will read the coding (3) associated with the text image being viewed thereby activating means (8.9,6) to produce a predetermined audio or visual response (10) appropriate to that being viewed.

2. Apparatus in accordance with claim 1, characterised in that; said machine readable coding (3) is superimposed on said text or images.

3. Apparatus in accordance with claim 1 or claim 2, characterised in that; the apparatus further comprises remotely of said wand or mouse (4) a computer (8,9) which controls and receives signals from the code reading device (7) and which further processes said received signals to produce the predetermined response (10).

4. Apparatus in accordance with any one of the preceding claims, characterised in that; each element of the machine readable coding is a respective bar code (3) comprising a plurality of bar positions (11A to 11D) each represented by either a bar or space.

5. Apparatus in accordance with claim 4, characterised in that; each bar code (3) consists of a sum total of four bar positions (11A to 11D).

6. Apparatus in accordance with claim 4, characterised in that; each bar code (3) consists of a sum total of eight bar positions with alternate positions (12A to 12C) being control bars adapted for use with a scanning code reading device.

7. Apparatus in accordance with any one of claims 4 to 6, characterised in that; said code reading device comprises a light source (13) for illuminating a given bar code (11A to 11D) and a plurality of photodetectors (15A to 15D) each adapted to receive light reflected from a corresponding bar position of said bar code.

8. Apparatus in accordance with claim 7, characterised in that; said light source (13) comprises a plurality of LED's each adapted to illuminate a corresponding bar position of said given bar code.

9. Apparatus in accordance with claim 6, characterised in that; said code reading device comprises a light source for illuminating a given bar code and a single photodetector adapted to reciprocate in a fixed path relative to the window to scan sequentially each bar position of said bar code to receive light reflected therefrom.

10. Apparatus in accordance with claim 9, characterised in that; said light source is adapted to scan sequentially each bar position in register with said scanning photodetector.

11. Apparatus in accordance with claim 10, characterised in that; said light source comprises a plurality of LED's each of which radiates light of a different wavelength and wherein said photodetector is adapted to discriminate between said different wavelengths.

12. Apparatus in accordance with any one of the preceding claims, characterised in that; the window of the wand (4) is glazed with a magnifying lens.

13. Apparatus in accordance with any one of the preceding claims, characterised in that; the wand or mouse (4) further comprises a flat LCD video screen (6) for displaying said visual response (10).

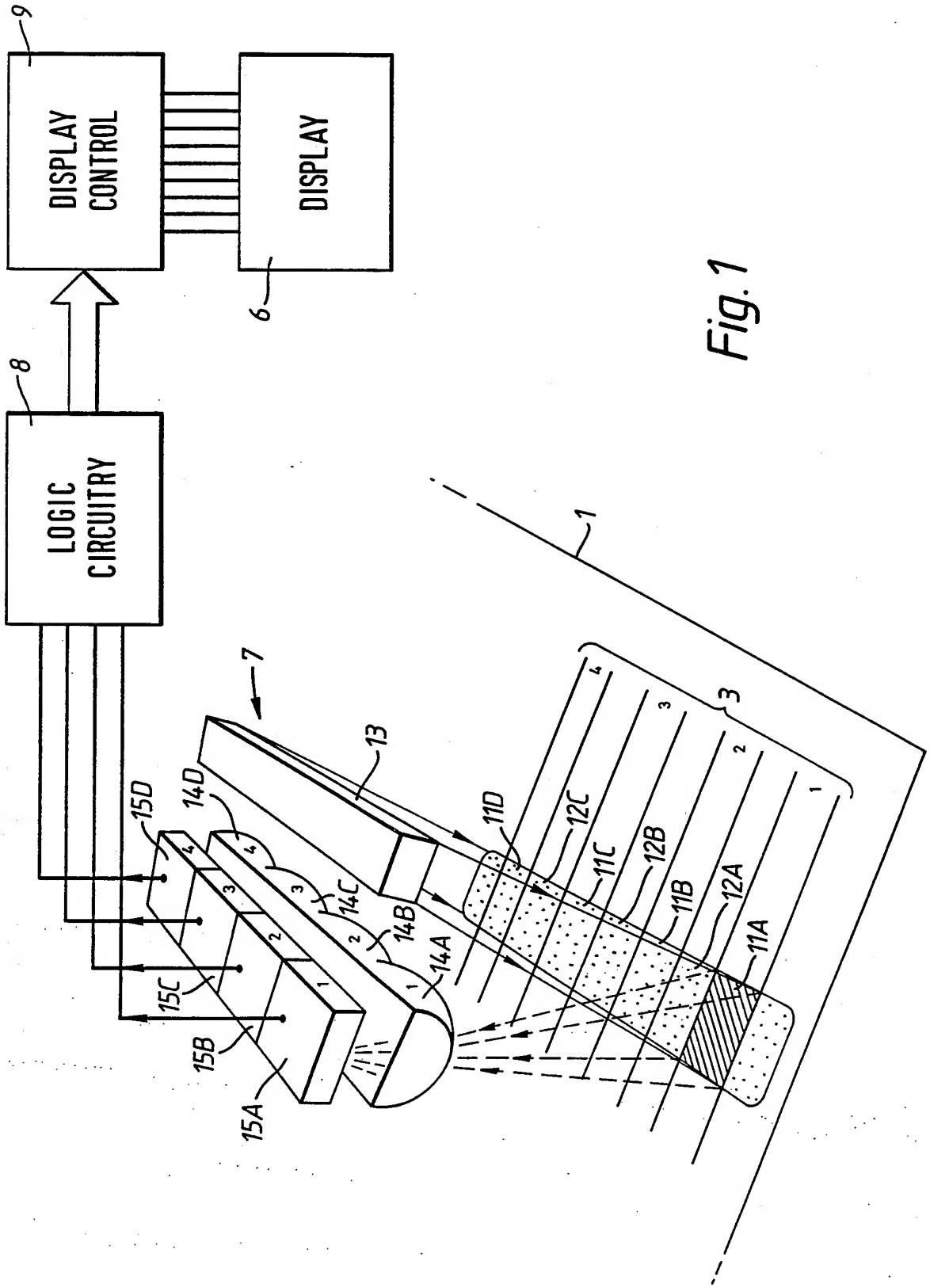
14. Apparatus in accordance with any one of the preceding claims, characterised in that; the code reading device (20) comprises a housing (21), a light source (24) and a photodetection device (31), the housing defining a chamber (22) illuminated by the light source (24) from which light is received by the photodetection device (31), a portion of the

interior surface of the chamber (22) being a plain mirrored surface (28,29), an aperture (23) in the chamber wall arranged to extend in use over a code segment on the printed substrate, the light source (24) providing a generally collimated beam (27) of light directed from the chamber (22) through the aperture (23), in which in use the beam (27) is reflected directly from the substrate to impinge on the mirrored surface (28,29) so as to be reflected through the aperture (23) with the arrangement providing that the beam having been reflected from the substrate at least twice is subsequently received by the photodetection device (31).

15. Apparatus in accordance with claim 14, characterised in that; the code reading device (20) comprises a plurality of portions of the interior surface being plain mirrored surfaces (28,29) each adapted in use to direct light reflected from the substrate back through the aperture (23).

16. Apparatus in accordance with claim 14 or claim 15, characterised in that; the non-mirrored interior surface (33) is coated with a retro-reflective substance adapted in use to reflect back stray light received from the printed substrate.

17. Apparatus in accordance with any one of the claims 14 to 16, characterised in that; the photodetection device (31) comprises a lens arrangement (30) adapted to collect light from the interior of the chamber and focus that light on a photodetector (32).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DISPLAY CONTROL
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6
8
LOGIC CIRCUITRY
1
7
13
3
15D
14D
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Fig. 1

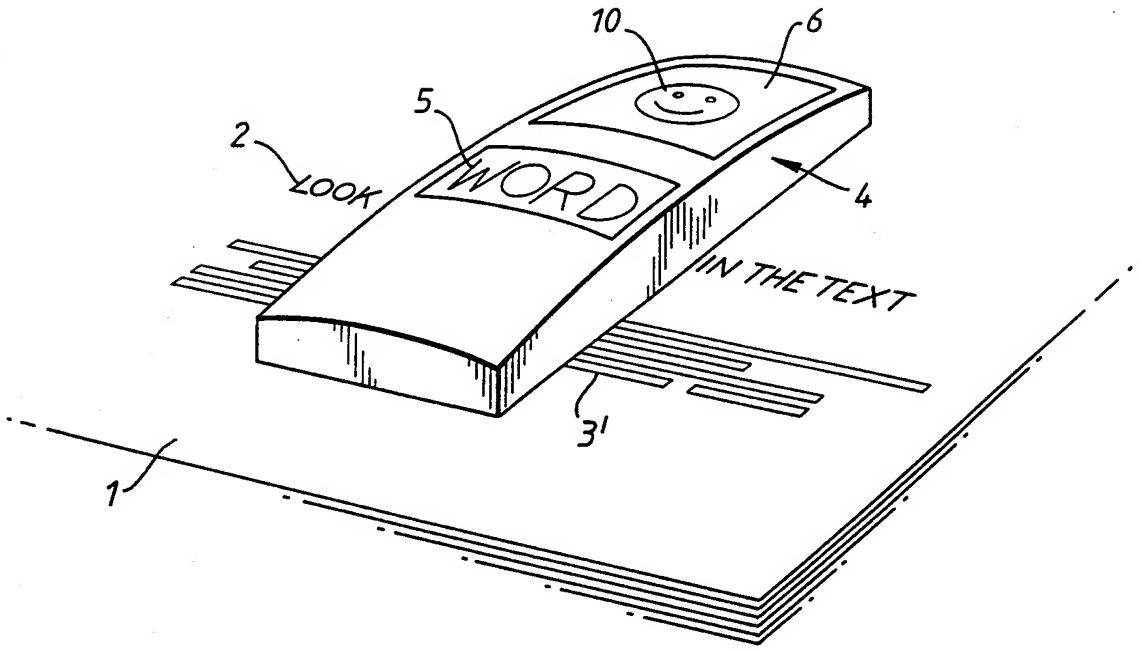

Fig. 1A

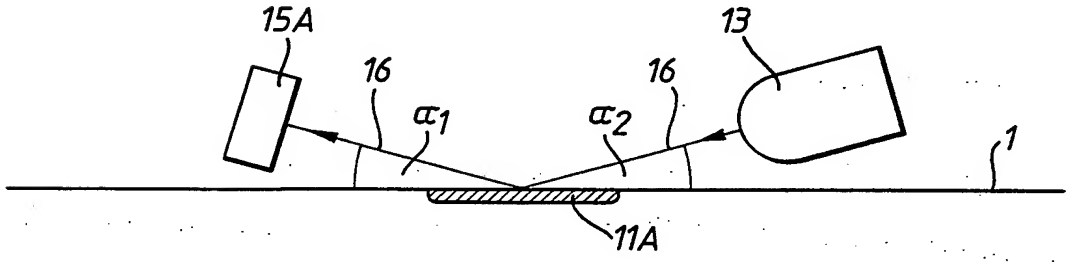

Fig. 2

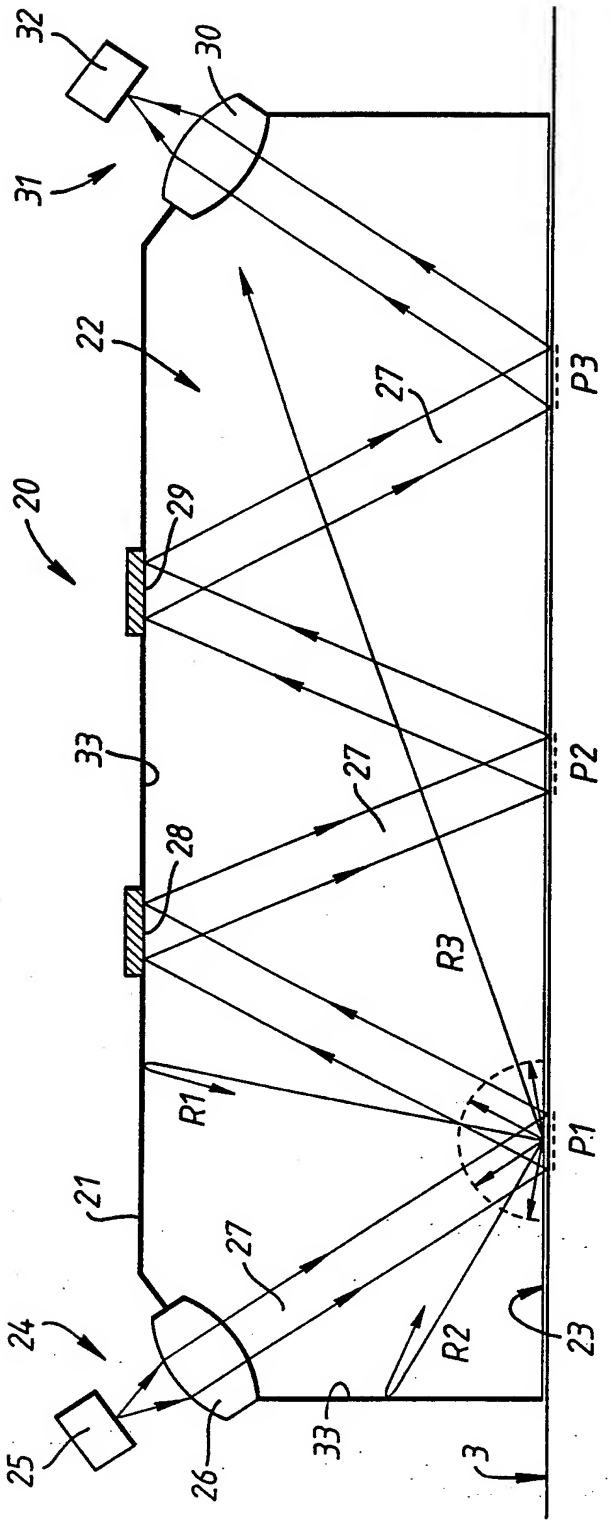

Fig.3

INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/GB 95/00864

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G09B7/06 G09B5/06 G09C5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G09B G09C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 212 558 (OBATA KENZO ET AL) 18 May 1993 see column 6, line 58 - column 8, line 13; claims 1-3,6; figures 6,7	1,4
A	---	2,3,7,13
Y	FR,A,2 515 391 (WESTERN PUBLISHING CY INC) 29 April 1983 see page 6, line 38 - page 13, line 30; claims 1,6,7; figures 1-7	1,4
A	---	3,7,12
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 July 1995	20. 07. 95

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/GB 95/00864

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 016 no. 463 (P-1428) ,25 September 1992 & JP,A,04 165581 (TOUKEN:KK;OTHERS: 01) 11 June 1992, see abstract	1,4
A	---	7,8
A	EP,A,0 300 729 (EMPIRE AIRPORT SERVICE KK) 25 January 1989 see column 2, line 35 - column 5, line 38; claims 1-17; figures 2A-3	1-4,10

A	US,A,5 254 844 (KRICHEVER MARK J ET AL) 19 October 1993 see the whole document	1,3,4,9, 10,13

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A	PATENT ABSTRACTS OF JAPAN vol. 011 no. 291 (P-618) ,19 September 1987 & JP,A,62 086470 (NEC CORP;OTHERS: 01) 20 April 1987, see abstract	1,3,4,8, 10,12,13

A	US,A,5 198 648 (HIBBARD ROBERT H) 30 March 1993 see the whole document	1,4,14, 15,17

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Interr nal Application No
PCT/GB 95/00864

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		US-A-	5367152	22-11-94
		US-A-	5401948	28-03-95
		CA-A-	1327850	15-03-94
		EP-A-	0341717	15-11-89
		EP-A-	0595371	04-05-94
		JP-A-	2023482	25-01-90
		JP-B-	7038208	26-04-95
		US-A-	5412193	02-05-95
		US-A-	5410140	25-04-95
		US-A-	5191197	02-03-93
		US-A-	5170277	08-12-92
		US-A-	5306900	26-04-94
		US-A-	5374817	20-12-94
		US-A-	5250790	05-10-93
US-A-5107100	21-04-92	US-A-	5130520	14-07-92
		US-A-	5321246	14-06-94
		US-A-	5396055	07-03-95
		US-A-	5047617	10-09-91
		US-A-	5262628	16-11-93
US-A-5198648	30-03-93	EP-A-	0516837	09-12-92
		JP-T-	5505269	05-08-93
		WO-A-	9212499	23-07-92